University of Tripoli – Faculty of Engineering

Electrical & Electronic Engineering Department

LPF

EE463 Final Exam- Time: 2 hr Spring 2019 25/9/2019

Q1) a-What is the meaning of single ended signal, differential signaland give example.

b- What is sample and what is hold and when we use them. [6 pts]

0.39

Q2) Using Temperature sensor (RTD-PT100),in the range (30C to 90C) and using Wheatstone bridge (Vs=9V, R1=110, R2=120),and using voltage to frequency converter VFC (scale factor= 10KHz/1.12V) .

a- Calculate the sensor output range, Wheatstone bridge output range and VFC output range.

b- Using a counter to convert to digital with sampling rate 180 sample/Sec,What is the output range of the counter, what is the value of the output of the counter if the temperature is ~~130~~C . 55C°

c- Draw Block diagram of the circuit. [16 pts]

Q3) An accelerometer sensor sensitivity is 0.145mA/ g , used for measuring pressure in the range (± 20 g). and the value of its output @ 0 g is 5.2mA, using 190 Ω ~~converting to~~ volt resistance ,~~Design signal~~ condition circuits for bipolar (8 bit) ADC with voltage reference ±4V.

a) Calculate sensor output range (current,voltage,Binary). $= \frac{\text{input} + V_{ref}}{\Delta V}$

b) What is the digital output of ADC at the acceleration is 8 g.

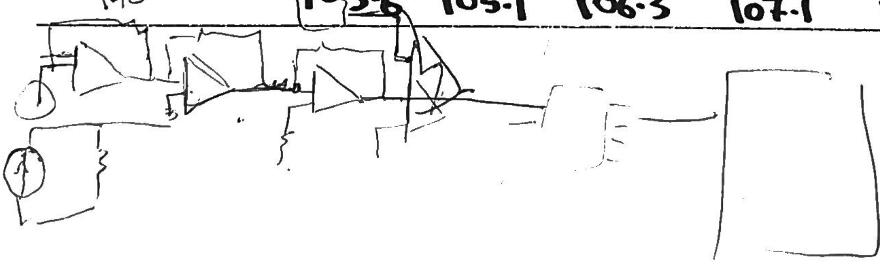
c) What is the value of acceleration when the digital output is 0DH,92H. [15 pts]

d) If the frequency of the signal is 120Hz and there is unwanted noise with frequency 15KHz, design filter that attenuate the noise to 18% of its value, calculate the effect on the sensor output range. [05 pts]

Q4) Using RTD with the following table using Quadratic approximation of resistance versus temperature find the value of the RTD at 12.4°C.

Temperature (°C)	0	5	10	15	20
Resistance (Ω)	103.6	105.1	106.3	107.1	108.3
190	103.6	105.1	106.3	107.1	108.3

[08 pts]



Good Luck (Zeyad)

Final Exam — Spring 2019 — اجوبة نماذج امتحانات

Q (2) RTD-PT 100 , $(30^\circ \sim 90^\circ C)$, Wheatstone bridge $\left(V_s = 9V , R_1 = 110\,\Omega ;\ R_2 = 120\,\Omega\right)$

VFC (10 KHZ / 1.12V)

$-\left((30 \times 0.39) + 100\,\Omega \sim (90 \times 0.39 \frac{\Omega}{C^\circ}) + 100\right) \Rightarrow (111.7\,\Omega \sim 135.1)$ Sensor o/P

$110 * 111.7 = 120 * R_3 \Rightarrow R_3 = 102.39$

- $R_1 R_4 = R_2 R_3 \Rightarrow$

$V_{b_1} = 9 \times \frac{111.7\,\Omega}{111.7 + 120} = 4.339$

- $V_a = 9 \times \frac{102.39}{102.39 + 110} = 4.339\,V ,$

$V_{b_2} = 9 \times \frac{135.1}{135.1 + 120} = 4.766\,V ,$ $\quad V_{b_1} - V_a = 0\,V$

$V_{b_2} - V_a = 0.427\,V$

- Wheatstone bridge o/P Range $(0 \sim 0.427\,V)$
- VFC o/P Range $(0 \sim 3.8125\,KHZ)$
- Counter o/P " $\left(\frac{1}{180}\,sec\right) \Rightarrow (0 \sim 21.18$ Pulse$)$

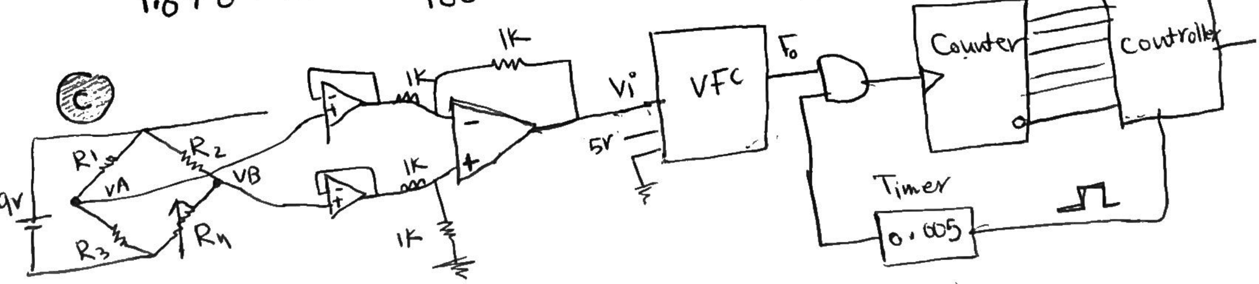
(b) $T = 55^\circ \longrightarrow$ Counter o/P $\Rightarrow$!?

$(55 \times 0.39) + 100 = 121.45\,\Omega \Rightarrow V_b = 9 \times \frac{121.45}{121.45 + 120} = 4.527$

$V_b - V_a = 0.188\,V \Rightarrow 0.188 \times \frac{10\,KHZ}{1.12\,V} = 1.678\,KHZ$

$1.678\,KHZ \times \frac{1}{180}\,sec = 9.32$ Pulse #

(c)



Q(3) 0.14 mA/g ($\pm$ 20g) @ 0g = 5.2 mA

R = 190 Ω (8 bit) ADC $\pm$4 V reference

Q(4

a

$((-20 \times 0.14) + 5.2) \sim ((20 \times 0.14) + 5.2) \Rightarrow (2.4 \sim 8\,mA)$ sensor O/P

$(0.456\,V \sim 1.52\,V)$ Range in Volt , $(142 \sim 176)$ Digital O/P

$\Delta V = \frac{8}{2^8} = 0.03125$, Digital o/P = $\frac{\text{analog I/P} + 4}{\Delta V}$

$(10001110 \sim 10110000)$ o/p Range in binary

b Digital o/P for 8g

$(8 \times 0.14) + 5.2 = 6.32\,mA \rightsquigarrow 6.32 \times 190 = 1.2\,V$

$(1.2+4)/0.03125 = 166 \rightsquigarrow (10100110)_2$

c accelaration value if a/p $(\overset{1}{0D}, \overset{2}{92})$

$(00001101)_2$, $(10010010)_2$

$\Downarrow$ $\Downarrow$

$(13)_{10}$ $(146)_{10}$

analog I/P = $\overset{1}{-3.594\,v}$, $\overset{2}{0.5625\,v}$

in mA = out of Range, 2.9 mA

accelaration = , −16.42 g

d $F_s = 120\,HZ$, $F_N = 15\,KHZ$, attenuate Noise 18%.

$$18\% = \frac{1}{\sqrt{1+\left(\frac{15KHZ}{F_c}\right)^2}} \Rightarrow F_c = 2745\,HZ$$

$$\text{effect on The o/P} = \frac{1}{\sqrt{1+\left(\frac{120}{2745}\right)^2}} = 99.9\%$$ very Good

"Low Pass filter"

Q(4)

°C	0	5	10	15	20
Ω	103.6	105.1	106.3	107.1	108.3
	①		⓪		②

$T = 12.4°C$

$$R(T) = R(T_0)\left(1 + \alpha \Delta T + \alpha_2 \Delta T^2\right)$$

$$108.3 = (106.3)\left(1 + 2.211 \times 10^{-3}(10) + \alpha_2 (10)^2\right)$$

$$\alpha_2 = -3.295 \times 10^{-5}$$

$$\alpha = \frac{1}{R(T_0)} \times \frac{R_2 - R_1}{T_2 - T_1}$$

$$= \frac{1}{106.3} \times \frac{108.3 - 103.6}{20 - 0}$$

$$= 2.211 \times 10^{-3}$$

$T = 12.4°C \rightarrow \Delta T = 2.4$

$$R(T) = 106.3\left(1 + 2.211 \times 10^{-3} \times 2.4 - 3.295 \times 10^{-5} \times (2.4)^2\right)$$

$$R(T) = 106.84\ \Omega$$

Final Fall - 2018

Q(1) RTD-PT100 $(22 \sim 190°C) \rightarrow (0 \sim 3V)$, ADC, Voltage Divider

$V_s = 9V$, $R_1 = 200$

(a) $\left(\left(22 \times 0.39\right) + 100\right) \sim \left(\left(190 \times 0.39\right) + 100\right) \Rightarrow (108.58 \sim 174.1\ \Omega)$

$$V_1 = 9 \times \frac{108.58}{108.58 + 200} = 3.16,\quad V_2 = 9 \times \frac{174.1}{174.1 + 200} = 4.18,\quad (3.16 \sim 4.18\ V)$$

$0 = 3.16M + \text{offset}$

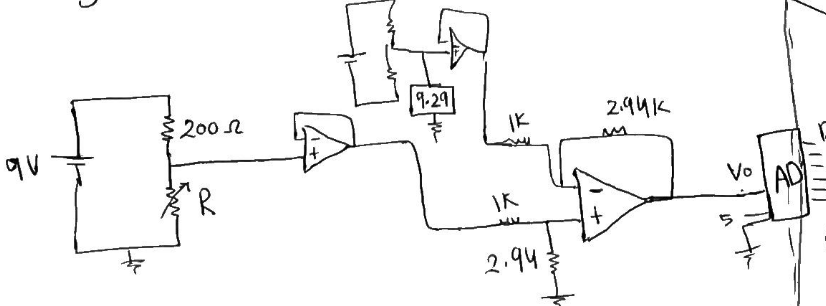
$3 = 4.18M + \text{offset}$

$3 = 1.02M$

$\Rightarrow M = 2.94$, offset $= -9.29$ $\Rightarrow \boxed{V_0 = 2.94V_i - 9.29}$

112 B

10 1B



~~$\Delta V = \frac{3}{2^8} = 0.0117$~~

~~Digital o/p = $\frac{\text{analog I/P}}{0.0117}$~~

~~$(\text{[illegible]})_{10}$~~

~~([illegible],~~

~~$(0 \sim 256)_{10}$~~

(c) $100^\circ C$

$(100 \times 0.39) + 100 = 139\,\Omega \Rightarrow 9 \times \dfrac{139}{139 + 200} = 3.69\,V$

$V_o = 2.94 \times 3.69 - 9.29 = 1.5586\,V$ # , Digital O/P = 133

في حاجة مش مفهومة في [illegible] ؟! لكن الأرقام صح تمام

Q(2) $S = 0.14\,mA/g$, @ $0g = 7\,mA$ $(\pm 30g)$, VFC $(4V/6KHz)$

(b)

$(-30 \times 0.14) + 7 = 2.8\,mA$, $(30 \times 0.14) + 7 = 11.2\,mA$, $(2.8 \sim 11.2\,mA)$

$R = 100\,\Omega \rightarrow (0.28\,V \sim 1.12\,V)$

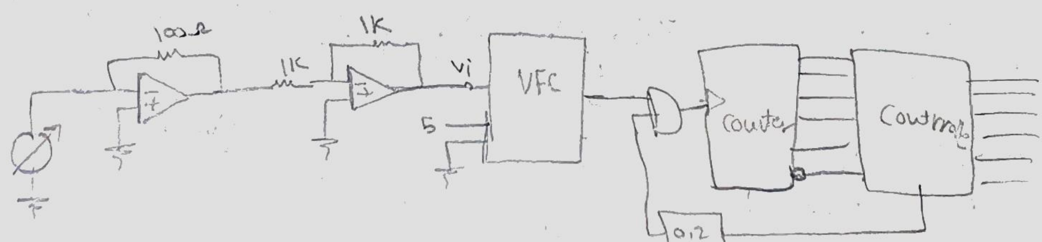
$\dfrac{1}{4/6}\ \dfrac{KHz}{V} \rightarrow (0.42\,KHz \sim 1.68\,KHz)$

$T = 0.2\ sec \rightarrow (84 \sim 336\ \text{Pulse}) \rightarrow (01010100,\ 101010000)_2$

(c) $(-0.5g) \rightarrow (-0.5 \times 0.14) + 7 = 6.93\,mA \times 100\,\Omega = 0.693\,V$

$\rightarrow 1.0395\,KHz \times 0.2\ sec = 208\ \text{Pulse} \rightarrow (11010000)_2$

(d)



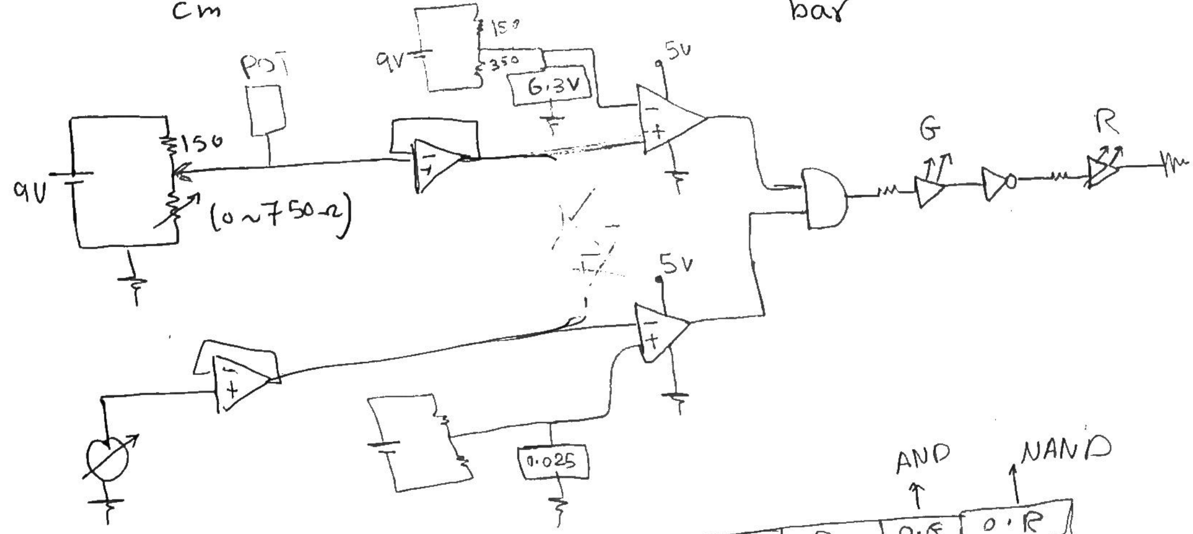
Q(3) $S = 5\,mV/bar$, $5\,\Omega/cm$ POT , 150 cm

$(V_s = 9V,\ R_1 = 150\,\Omega)$ Green $L > 70\,cm$

$P < 5\,bar$

لـ وحدة مترى ref

$150 \times \frac{5\Omega}{cm} = 750\Omega$, $5bar \times 5\frac{mV}{bar} = 25mV$



A	B	O.G (AND)	O.R (NAND)
0	0	0	X
0	1	0	1
1	0	0	1
1	1	1	0

Q(4) قيم مش واضحة

Q(5) $V = 19mV$ $T = ?$, $T = -40°$ $V = ?$ K-Type

$V = -1.50 mV$ #

$V_L = 18.94$, $V_H = 19.15$

$T_L = 460$, $T_H = 465$

$$V_m = V_L + \left(\frac{V_H - V_L}{T_H - T_L}\right)(T_m - T_L) \Rightarrow 19 = 18.94 + \left(\frac{19.15 - 18.94}{5}\right)(T_m - 460)$$

$T_m = 461.43°$

Final Spring 2018

Q(2) $S = 5mV/°C$, $(30 \sim 120°C)$, VFC $(2V/1KHZ)$

sensor o/p Range $(30 \times 5 \sim 120 \times 5) \rightarrow (0.15 \sim 0.6V)$

VFC o/p Range $(0.15 \times \frac{1}{2/1} \sim 0.6 \times \frac{1}{2}) \rightarrow (75 \sim 300 HZ)$

Counte o/p Range $(75 \times \frac{1}{10} \sim 300 \times \frac{1}{10}) \rightarrow (7.5 \sim 30 \text{ pulse})$

$T = 112°c \rightarrow 112 \times 5 \frac{mv}{C} = 0.56\ V \rightsquigarrow 0.56v \times 0.5 \frac{KHZ}{V} = 0.2$

$280HZ \times \frac{1}{10} = 28$ Sample #

Q(3) $S = 0.13 mA / bar$, $(-20 \sim +20 \overset{\hat{=}\ bar}{g})$, @ $\ominus$ bar $= 4 mA$, $R = 150$

ADC (8bit , $\pm 4V$ ref)

sensor o/p $(-20 \times 0.13) + 4 \sim (20 \times 0.13) + 4 \Rightarrow (1.4 \sim 6.6\ mA)$

$\Rightarrow (1.4 \times 150 \sim 6.6 \times 150) \rightsquigarrow (0.21 \sim 0.99\ V) \overset{\text{Digital o/P}}{\rightsquigarrow} (135 \sim 160)$

$\Delta V = \frac{8}{2^8} = 0.03125$ Digital o/P $= \frac{\text{analog I/P}}{0.03125}$

ⓐ $(P = 8\ bar) \Rightarrow (8 \times 0.13) + 4 = 5.04\ mA \times 150\ \Omega = 0.756\ V$

Digital o/P $= \frac{0.756 + 4}{0.03125} = (152)_{10} \rightarrow$

128 64 32 16 8 4 2 1

$(10011000)_2$

ⓑ (Digital o/P = 18H) $\Rightarrow (18)_H = (00011000)_2 = (24)_{10}$

analog I/P $= (24 \times 0.03125) - 4 = -3.25\ V$ OUT OF RANGE

Q(4) "رحة في الورقة/"

$$\text{DAC} = \overset{0\ 1\ 2\ 3\ 4\ 5\ 6\ 7}{(01010101)_2} \Rightarrow (85)_{10} \Rightarrow \text{analog I/P } (0.664)^{\text{Volt}}$$

$\Delta V = \frac{2}{2^8} = 7.8125 \times 10^{-3}$, Digital o/P $= \frac{\text{ang I/P}}{7.8125 \times 10^{-3}}$

$V_o = \left(\frac{R_f}{R} + 1\right) V_i = \left(\frac{1.7}{1} + 1\right) \times 0.664 = 1.7928\ V$ #

$\Delta V = \frac{5}{2^8} = 0.0195$, Digital o/P $= \frac{1.7928}{0.0195} = (92)_{10}$

$(01011100)_2$

Q(5) ref = 40°C V = ? if T = 120°C J- Type (a)

$$V_{J40}(120) = V_{J_0}(120) - V_{J_0}(40)$$

$$6.36 - 2.06 = 4.3\cancel{7} \text{ mV}$$

(b)

	①		⓪		②
C°	0	5	10	15	20
Ω	107.6	109.1	110.2	111.1	111.7

$$\boxed{T = 11.4^\circ C}$$

$$R(T) = R(T_0) * (1 + \alpha\Delta T + \alpha_2 \Delta T^2) \quad , \alpha = \frac{1}{R(T_0)} \cdot \frac{R_2 - R_1}{T_2 - T_1}$$

~~T = 111.7~~, : Assume $R(T) = 111.7$.

$$111.7 = 110.2 \times (1 + 1.86 \times 10^{-3} \times 10 + \alpha_2 \times 100)$$

$$\alpha = \frac{1}{110.2} \cdot \frac{111.7 - 107.6}{20}$$

$$\alpha = 1.86 \times 10^{-3} \ \#$$

$$\alpha_2 = -4.98 \times 10^{-5}$$

$T = 11.4^\circ C \rightarrow$

$$R(T) = 110.2 \times (1 + 1.86 \times 10^{-3} \times (11.4 - 10) - 4.98 \times 10^{-5} (11.4 - 10)^2)$$

$$R(T) = 110.47^\circ C \ \#$$

Final Spring 2017

Q(1) $S = 4\,\Omega/°C$ $(\pm 25°C)$ @ $0°C = 280\,\Omega$, Wheatstone Ω/V + use Transm

(8bit, 0~5V) ADC

$$((-25 \times 4) + 280 \sim (25 \times 4) + 280) \rightsquigarrow (180\,\Omega \sim 380\,\Omega)$$

$R_1 = 100$, $R_2 = 120$, $V_s = 9V$

$$R_1 R_4 = R_2 R_3$$

$$100 \times 180 = 120 \times R_3 \rightarrow R_3 = 150\,\Omega$$

$$V_a = 9 \times \frac{150}{150 + 100} = 5.4 \text{ V}, \quad V_{b_1} = 9 \times \frac{180}{180 + 120} = 5.4 \text{ V}$$

$$V_{b_2} = 9 \times \frac{380}{380 + 120} = 6.84 \text{V} \rightarrow (0 \sim 1.44 \text{ Volt})$$

$V_o = V_i + 1$ using Transmitter $\rightarrow$ $(1 \sim 2.44 \text{ Volt})$

$\Delta V = \frac{5}{2^8} = 0.0195$, $(51 \sim 125)_{10} \rightarrow$ Digital O/P

$(00110011, \quad 01111101)_2$

△a $T = -2^\circ C \rightarrow (-2 \times 4) + 280 = 272\ \Omega$

$V_b = 9 \times \frac{272}{272 + 120} = 6.24 \rightsquigarrow (6.24 - 5.4) = 0.844\ V + 1 = 1.844$

Digital O/P $= (94)_{10} \rightsquigarrow (01011110)_2$

Q(2) $S = 0.33\ mA/g$ $(\pm 20g)$ ADC (8bit , ∓ 4)

Sensor O/P $(-20 \times 0.33) \sim (20 \times 0.33) \Rightarrow (-6.6 \sim 6.6\ mA)$ Assume $R = 100\Omega$

$(-0.66 \sim 0.66\ V)$ [need Transmitter $(0.34 \sim 1.66\ V)$] → غير مطلوب

$\boxed{\Delta V = \frac{8}{2^8} = 0.03125}$, $(107 \sim 149)_{10} \rightarrow$ Digital O/P

△a $(-3g) \rightarrow -3 \times 0.33 = -0.99\ mA \times 100 = -0.099\ V$

Digital O/P $\rightarrow (124)_{10} \rightarrow (01111100)_2$

△b $(06\ H) \rightarrow (0000\ 0110)_2 \rightarrow (6)_{10}$ OUT OF RANGE

Q(3) (10 bit (0~5V)) ADC , Sensor O/P (± 150mV)

$F_s = 15\ Hz$, $V_N = 20mV$, $F_N = 150\ HZ$, attenuate (25%)

$\Delta V = \frac{5}{2^{10}} = 4.88 \times 10^{-3}$

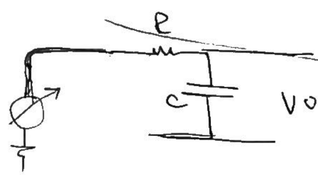
$25\% = \frac{1}{\sqrt{1 + \left(\frac{150}{F_c}\right)^2}} \Rightarrow F_c = 38.72\ HZ$

$V_o / V_i = \frac{1}{\sqrt{1 + \left(\frac{15}{38.72}\right)^2}} = 0.9324 \rightsquigarrow 93.2\%$ Good

i/p (−150 mV ~ 150 mV) $\xrightarrow{+20\,mV}$ (−0.13 ~ 0.17 V)

effect of filter in sensor o/p $(-0.13 \times 0.9324) \sim (0.17 \times 0.9324)$

$(-0.12 \sim 0.16\,V)$ #



$V_o = V_i + 1 \rightarrow (0.88 \sim 1.16\,V)$

Digital o/p $(180 \sim 237)_{10}$

$(00010100, 00111011101)_2$

Q(4) Type-J

(a) $T = 32^\circ c$ $V = ?$

(b) $T > 32^\circ c \rightarrow$ ON Cooler

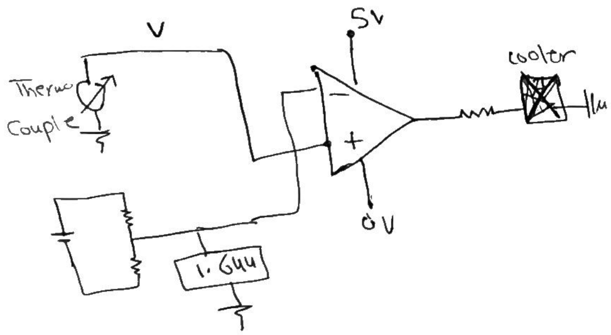
(a) $T_L = 30$, $V_L = 1.54$

$T_H = 35$, $V_H = 1.8$

$$T_m = T_L + \left(\frac{T_H - T_L}{V_H - V_L}\right)(V_m - V_L)$$

$$32 = 30 + \left(\frac{5}{0.26}\right)(V_m - 1.54)$$

$V_m = 1.644$ #



(c) $T = 13^\circ c \rightarrow \Omega = ?!$, $T < 13 \rightarrow$ ON heater

	1		0		2
C°	0	5	10	15	20
Ω	107.6	109.1	110.2	111.3	111.7

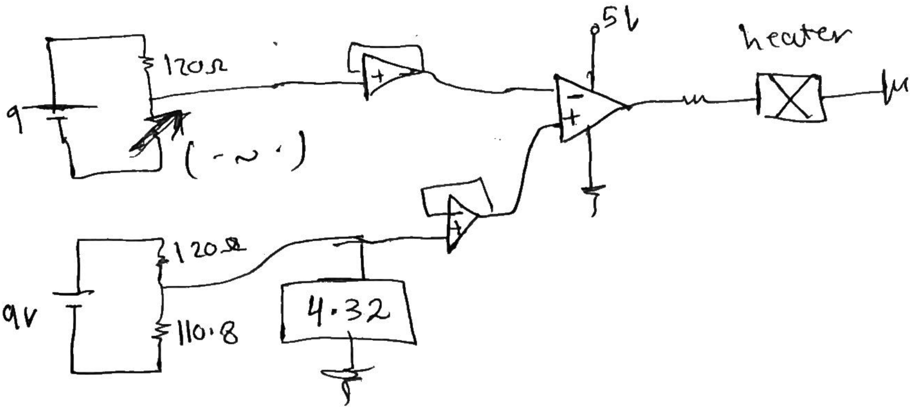
$$\alpha = \frac{1}{R(T_0)} \times \frac{R_2 - R_1}{T_2 - T_1} = 1.86 \times 10^{-3}$$, $R(T) = R(T_0)(\alpha \Delta T + 1)$

$R(T) = 110.2\,(1 + 1.86 \times 10^{-3} \times 3)$

$R(T) = 110.8\,\Omega$ #

$$V = 9 \times \frac{110.8}{110.8 + 120} = 4.32\,V \#$$

Assume $R = 120\,\Omega$, $V_s = 9\,V$



Q(3) S-19 Final

(a) $(0.456\ V \sim 1.52\ V)$

$-4 = 0.456M + F$
$4 = 1.52M + F$
$8 = 1.064M$

$M = 7.518$
$F = -7.428$

$V_o = 7.518 V_i - 7.428$

$(-4 \sim 4\ v)$
$\rightarrow (0 \sim 256)_{10}$

(b) $(89 \times 0.14) + 5.2 = 6.32\ mA \times 190\ \Omega = 1.2\ V \rightsquigarrow 1.5936\ V$

Digital $O/P \approx (178)_{10} \rightarrow (10110010)_2$

(c) OD → 13 , 92 → 146

$D_o \times \Delta V \doteq -3.59$, 0.5625

$V_o = V_i M + F = 0.51\ V$, $1.6628\ V$

$V/R = I = 2.68\ mA$, $5.59\ mA$

$g = -18\ g$, $2.79\ g$

Q(3) S-18 final

$(0.21 \sim 0.99)\ v$,

$-4 = 0.21M + F$
$4 = 0.99M + F$
$8 = 0.78M$

$M = 10.25$
$F = -6.15$

$V_o = 10.25 V_i - 6.15$

(a) $(8 \times 0.13) + 4 = 5.04\ mA \times 150\ \Omega = 0.756\ V \rightsquigarrow$ ~~2.27~~ V 1.599

$(179)_{10} \rightarrow (10110011)_2$

(b) $(18)_H \rightarrow (24)_{10} \rightarrow -3.25\ V \rightarrow 0.28\ V \rightsquigarrow 1.88\ mA$

$(-16.25)\ g$